

TriStar MODBUS Specification  
Morningstar Corporation

V 04  
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## Parameters

The TriStar supports communication via its serial RS-232 interface and uses the industry standard MODBUS application protocol. This document assumes the user is familiar with the MODBUS protocol and its terminology. Please refer to the documents listed in the [References](#) section for more information.

### **Modbus™ is a trademark of Modicon, Inc.**

The TriStar supports RTU mode only.

16bit MODBUS addresses (per the modbus.org spec)

The serial communication parameters are

- BPS: 9600 baud
- Parity: None
- Data bits: 8
- Stop bits: 2
- Flow control: None

All addresses listed are for the request PDU.

The TriStar defaults to server address of 0x01.

## Supported Modbus Functions

### *Read Holding Registers (0x03) and Read Input Registers (0x04)*

#### RAM

PDU Addr	Logical Addr	Variable name	Variable description	Units	Scaling or Range
0x0000	1		Internal Use		
0x0001	2		Internal Use		
0x0002	3		Internal Use		
0x0003	4		Internal Use		
0x0004	5		Internal Use		
0x0005	6		Internal Use		
0x0006	7		Internal Use		
0x0007	8		Internal Use		
0x0008	9	<a href="#">adc_vb_f</a>	Battery voltage, filtered ( $\tau \approx 2.5s$ )	V	$n \cdot 96.667 \cdot 2^{-15}$
0x0009	10	<a href="#">adc_vs_f</a>	Battery sense voltage, filtered ( $\tau \approx 2.5s$ )	V	$n \cdot 96.667 \cdot 2^{-15}$
0x000A	11	<a href="#">adc_vx_f</a>	Array/Load voltage, filtered ( $\tau \approx 2.5s$ )	V	$n \cdot 139.15 \cdot 2^{-15}$
0x000B	12	<a href="#">adc_ipv_f</a>	Charging current, filtered ( $\tau \approx 2.5s$ )	A	$n \cdot 66.667 \cdot 2^{-15}$
0x000C	13	<a href="#">adc_iloat_f</a>	Load current, filtered ( $\tau \approx 2.5s$ )	A	$n \cdot 316.67 \cdot 2^{-15}$
0x000D	14	<a href="#">Vb_f</a>	Battery voltage, slow filter ( $\tau \approx 25s$ )	V	$n \cdot 96.667 \cdot 2^{-15}$
0x000E	15	<a href="#">T_hs</a>	Heatsink temperature	°C	-128 to +127
0x000F	16	<a href="#">T_batt</a>	Battery temperature (RTS connected) (0x80 if not connected)	°C	-128 to +127
0x0010	17	<a href="#">V_ref</a>	Charge regulator reference voltage	V	$n \cdot 96.667 \cdot 2^{-15}$
0x0011	18	<a href="#">Ah_r_HI</a>	Ah resetable, HI word	Ah	$n \cdot 0.1$
0x0012	19	<a href="#">Ah_r_LO</a>	Ah resetable, LO word	-	
0x0013	20	<a href="#">Ah_t_HI</a>	Ah total, HI word	Ah	$n \cdot 0.1$
0x0014	21	<a href="#">Ah_t_LO</a>	Ah total, LO word	-	
0x0015	22	<a href="#">hourmeter_HI</a>	hourmeter, HI word	h	0 to ( $2^{24}-1$ )
0x0016	23	<a href="#">hourmeter_LO</a>	hourmeter, LO word	-	
0x0017	24	<a href="#">Alarm_LO</a>	alarm bitfield	-	
0x0018	25	<a href="#">fault</a>	fault bitfield	-	
0x0019	26	<a href="#">dip_switch</a>	dip switch settings at power on switch[1..8] in bits[0..7]	-	
0x001A	27	<a href="#">control_mode</a>	Control mode (0=charge, 1=load, 2=diversion)	-	
0x001B	28	<a href="#">control_state</a>	Control state	-	
0x001C	29	<a href="#">d_filt</a>	PWM Duty Cycle	-	0-255
0x001D	30	<a href="#">Alarm_HI*</a>	Alarm bitfield (continued from 0x0017)	-	

**\*Note:** Alarm\_HI(0x001D) not addressable for software version 1.04.02 or older.

## EEPROM

PDU Addr	Logical Addr	Variable name	Variable description	Write allowed	Units	Scaling or Range
			Charge and diversion mode			
0xE000	57345	<a href="#">EV_reg</a>	Regulation voltage @ 25°C	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE001	57346	<a href="#">EV_float</a>	Float voltage @ 25°C Set to zero to disable float	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE002	57347	<a href="#">Et_float</a>	time before entering float	✓	s	$0 - (2^{16} - 1)$
0xE003	57348	<a href="#">Et_floatlb</a>	time before entering float due to low battery	✓	s	$0 - (2^{16} - 1)$
0xE004	57349	<a href="#">EV_floatlb_trip</a>	Voltage that triggers low battery float time	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE005	57350	<a href="#">EV_float_cancel</a>	Voltage that cancels float	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE006	57351	<a href="#">EV_eq</a>	Equalize voltage @ 25°C Set to zero to disable equalize	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE007	57352	<a href="#">Et_eqcalendar</a>	days between eq cycles	✓	days	0-255
0xE008	57353	<a href="#">Et_eq_above</a>	equalize time limit above Vreg	✓	s	$0 - (2^{16} - 1)$
0xE009	57354	<a href="#">Et_eq_reg</a>	equalize time limit at Veq	✓	s	$0 - (2^{16} - 1)$
0xE00A	57355	<a href="#">EV_tempcomp</a>	LSB only (note $2^{-16}$ scaling, negative sign is assumed)	✓	V	$n \cdot 96.667 \cdot 2^{-16}$
0xE00B	57356	<a href="#">EV_hvd</a>	High Voltage Disconnect @ 25°C Set to zero to disable HVD	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE00C	57357	<a href="#">EV_hvr</a>	High Voltage Reconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE00D	57358	<a href="#">Etmr_eqcalendar</a>	days since last equalize	✓	days	0-255
0xE00E	57359	<a href="#">Et_float_exit_cum</a>	Cum. time at 100% duty cycle, exit float	✓	s	$0 - (2^{16} - 1)$
0xE041	57410	<a href="#">Ed_float_enter</a>	Duty Cycle to begin Float transition counter	✓	%	0-100
0xE042	57411	<a href="#">Eb_diversion_pwm</a>	Diversion regulation type (PWM or On-Off)	✓	-	0 or 1
			Load mode			
0xE00F	57360	<a href="#">EV_lvd</a>	Low Voltage Disconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE010	57361	<a href="#">EV_lvr</a>	Low Voltage Reconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE011	57362	<a href="#">EV_lhvd</a>	Load High Voltage Disconnect Set to zero to disable HVD	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE012	57363	<a href="#">EV_lhvr</a>	Load High Voltage Reconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE013	57364	<a href="#">ER_icomp</a>	LVD Load current compensation	✓	Ω	$n \cdot 0.305 \cdot 2^{-16}$
0xE014	57365	<a href="#">Et_lvd_warn</a>	LVD warning timeout	✓	s	$n \cdot 0.1$
			Lighting Mode			
0xE015	57366	<a href="#">Et_sun1</a>	Lighting Time after sunset	✓	s	(signed)
0xE016	57367	<a href="#">Et_sun2</a>	Lighting time before sunrise	✓	s	(signed)
0xE017	57368	<a href="#">Eb_light_config</a>	Lighting Configuration Bits	✓	-	
0xE018	57369	<a href="#">EV_night_max</a>	Night time threshold – Array Voc	✓	V	$n \cdot 139.15 \cdot 2^{-15}$
0xE019	57370	<a href="#">EV_day_min</a>	Morning threshold for timing – Array Voc	✓	V	$n \cdot 139.15 \cdot 2^{-15}$
0xE01A	57371	<a href="#">EV_relaxed_day</a>	Morning threshold for lighting – Array Voc	✓	V	$n \cdot 139.15 \cdot 2^{-15}$
			Common Values			
0xE01B	57372	<a href="#">EV_soc_g_gv</a>	common, LED green to green/yellow limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$

						15
0xE01C	57373	<a href="#">EV_soc_gy_y</a>	LED green/yellow to yellow limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01D	57374	<a href="#">EV_soc_y_yr</a>	LED yellow to yellow/red limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01E	57375	<a href="#">EV_soc_yr_r</a>	LED yellow/red to red limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01F	57376	<a href="#">ETb_max</a>	Max battery temp compensation limit	✓	°C	-128 to +127
0xE020	57377	<a href="#">ETb_min</a>	Min battery temp compensation limit	✓	°C	-128 to +127
0xE021	57378	<a href="#">Emb_tristar_id</a>	Modbus TriStar server ID	✓	-	1-247
0xE022	57379	<a href="#">Et_batt_service</a>	days between battery service intervals	✓	days	0-255
0xE023	57380	<a href="#">Etmr_batt_service</a>	days since last battery service	✓	days	0-255
0xE026	57383	<a href="#">Ehourmeter_LO</a>	hourmeter		h	0 to $(2^{24}-1)$
0xE027	57384	<a href="#">Ehourmeter_HI</a>				
0xE028	57385	<a href="#">EAh_r_LO</a>	Resettable Ah low byte		Ah	$n \cdot 0.1$
0xE029	57386	<a href="#">EAh_r_HI</a>	Resettable Ah high byte			
0xE02A	57387	<a href="#">EAh_t_LO</a>	Total Ah low byte		Ah	$n \cdot 0.1$
0xE02B	57388	<a href="#">EAh_t_HI</a>	Total Ah high byte			
0xE02C	57389	<a href="#">EkWh</a>	Kilowatt hours			
0xE02D	57390	<a href="#">EVb_min</a>	Minimum battery voltage		V	$n \cdot 96.667 \cdot 2^{-15}$
0xE02E	57391	<a href="#">EVb_max</a>	Maximum battery voltage		V	$n \cdot 96.667 \cdot 2^{-15}$
0xE040	57409	<a href="#">Emb_meterbus_id</a>	TriStar MeterBus ID	✓	-	1-15

## Calibration Values

PDU Addr	Logical Addr	Variable name	Variable description	Scaling or Range
0xF000	61441	<a href="#">serial[1].[0]</a>	serial number (8 byte ASCII string)	
0xF001	61442	<a href="#">serial[3].[2]</a>		
0xF002	61443	<a href="#">serial[5].[4]</a>		
0xF003	61444	<a href="#">serial[7].[6]</a>		
0xF004	61445	<a href="#">K_gain_adc_vb48</a>	Battery voltage divider calibration, 48V mode	$n \cdot 2^{-15}$
0xF005	61446	<a href="#">K_gain_adc_vb1224</a>	Battery voltage divider calibration, 12/24V mode	$n \cdot 2^{-15}$
0xF006	61447	<a href="#">K_gain_adc_ic</a>	Charge current calibration	$n \cdot 2^{-15}$
0xF007	61448	<a href="#">K_gain_adc_il</a>	Load current calibration	$n \cdot 2^{-15}$
0xF008	61449	<a href="#">K_gain_adc_vs</a>	Sense voltage calibration	$n \cdot 2^{-15}$
0xF009	61450	<a href="#">K_gain_adc_vx</a>	Array/Load voltage divider calibration	$n \cdot 2^{-15}$
0xF00A	61451	<a href="#">K_hw_ver[major, minor]</a>	MSB: hardware version major LSB: hardware version minor	
0xF00B	61452	<a href="#">calib_state, K_amp60</a>	MSB: calib_state = 0x5A if calibrated LSB: K_amp60 = 0x01 if TS60, 0x00 if TS45	
0xF00C- 0xF03F	61453- 61504	unused		

## *Read Coils (0x01), Read Discrete Inputs (0x02), Write Single Coil (0x05)*

PDU Addr	Logical Addr	Variable description
0x0000	1	<a href="#">Equalize triggered</a>

0x0001	2	<a href="#">Disconnect (1 will force control into a disconnect state)</a>
...	3-16	reserved
0x0010	17	<a href="#">Clear Ah resetable (set only, will always read 0)</a>
0x0011	18	<a href="#">Clear Ah total (set only, will always read 0)</a>
0x0012	19	<a href="#">Clear kWh (set only, will always read 0)</a>
0x0013	20	<a href="#">Reset batt service reminder (set only, will always read 0)</a>
0x0014	21	<a href="#">Clear faults (set only, will always read 0)</a>
0x0015	22	<a href="#">Clear alarms (set only, will always read 0)</a>
0x0016	23	<a href="#">Force EEPROM update (set only, will always read 0)</a>
0x0017	24	<a href="#">LVD override for one cycle (set only, will always read 0)</a>
...	25-254	reserved
0x00FF	256	<a href="#">Reset control</a>

## Logged Data

The TriStar (firmware v13 and later) stores approximately 90 days of data. This data is stored in a circular buffer where the oldest data is over-written by the newest data. The log data must be requested and sorted into correct order before the data will be useful.

- The logged data is mapped from 0x8000-0x8600 (3kB)
- The data consists of up to 96 blocks of data. (One block is generally one day w/ some exceptions)
- Each block is 32bytes (16 modbus variables)
- It is written in a circular buffer format. All blocks must be read and then put in linear order via the hourmeter field. Ignore blocks w/ hourmeters of 0x000000 or 0xFFFFFFFF. The largest hourmeter block is the most recent.

PDU Addr	Logical Addr	Variable name	Variable description
0x8000-8010	32769-32785	logger[0]	
...	...		
0x85F0-8600	34289 - 34305	logger[95]	

Data is stored in big endian format.

Shared Variables:

```
struct {
    Uint24 hourmeter;
    Uint16 Logger_flags;
    Uint24 alarm_daily;
    Uint16 Vb_max_daily;
    Uint16 Vb_min_daily;
    Uint16 Ah_daily;
    Uint16 Fault_daily;
    Uint8 Tb_min_daily;
```

```

    Uint8 Tb_max_daily;
}
Charge Control Variables:
struct {
    Uint16 T_ab_daily;
    Uint16 T_eq_daily;
    Uint16 T_fl_daily;
    Uint16 NO DATA[4];
}
Load Control Variables:
struct {
    Uint16 T_loadon_daily;
    Uint16 NO DATA[6];
}

```

Byte Offset	Variable name	Bytes	Variable description	Units	Scaling or Range
<b>Shared Log Variables</b>					
0	Hourmeter	3		h	0 to $(2^{24}-1)$
3	Logger_flags	2		-	
5	Alarm_daily	3	Alarm bitfield – daily	-	
8	Vb_max_daily	2	Vb minimum voltage – daily	V	$n \cdot 100 \cdot 2^{-15}$
10	Vb_min_daily	2	Vb maximum voltage – daily	V	$n \cdot 100 \cdot 2^{-15}$
12	Ah_daily	2	Ah – daily	Ah	$n \cdot 0.1$
14	Fault_daily	2	Fault bitfield – daily	-	
16	Tb_min_daily	1	Battery temp. minimum – daily	°C	-128 to +127
17	Tb_max_daily	1	Battery temp. maximum – daily	°C	-128 to +127
<b>Charge Only Log Variables</b>					
18	T_ab_daily	2	Time in absorption – daily	s	$0-(2^{16}-1)$
20	T_eq_daily	2	Time in equalization – daily	s	$0-(2^{16}-1)$
22	T_fl_daily	2	Time in float – daily	s	$0-(2^{16}-1)$
24-31			No Data		
<b>Load Only Log Variables</b>					
18	T_loadon_daily	2	Time load on – daily	s	$0-(2^{16}-1)$
20-31			No Data		

### ***Write Single Register (0x06)***

Any write to EEPROM will set an “EEPROM changed” fault. The control must be reset to clear this fault.  
 Note: No verify is performed on the write.

See EEPROM table in Read Input Registers(0x04).

### ***Read Device Identification (0x2B, subcode 0x0E)***

Only supports “basic device identification (stream access)” (ID code 0x01)

Object Id	Object Name/Description	Typical Value
-----------	-------------------------	---------------



0x00	VendorName	"Morningstar Corp."
0x01	Product Code	"TS-45" or "TS-60"
0x02	MajorMinorRevision (hardware major.minor. software revision)	"v01.01.01"

## Variables and Definitions

### Variable\_name

[Logical Address][PDU Address] (Units). *Short description.*  
Definition.

### ***Read Holding and Read Input Registers***

Located in processor RAM, updated continuously.

#### **adc\_vb\_f**

[09][0x008] (V). *battery voltage, filtered.*

Voltage measured directly at the battery connection on the TriStar.

#### **adc\_vs\_f**

[10][0x009] (V). *battery sense voltage.*

Voltage reading at the Battery Sense terminals. Battery sense provides the processor with an accurate reading of the battery voltage directly at the battery. The Battery Sense wires carry little current and therefore do not have a significant voltage drop between the battery and controller, providing accurate battery voltage measurement.

#### **adc\_vx\_f**

[11][0x00A] (V). *solar or load voltage.*

Depending on the control mode(Solar, Load, Diversion), Vx is the terminal voltage of the PV or load connection.

#### **adc\_ipv\_f**

[12][0x00B] (A). *solar current, filtered.*

Slow filtered charging current value as measured by on-board shunts.

#### **adc\_iloa\_f**

[13][0x00C] (A). *load current, filtered.*

Slow filtered load current value as measured by on-board shunts.

#### **Vb\_f**

[14][0x00D] (V). *battery voltage, slow filtered.*

Voltage measured directly at the battery connection on the TriStar. This value is heavily filtered and takes several seconds to settle if changes in voltage occur.

**T\_hs**

[15][0x00E] (C). *heatsink temperature*.

An on-board thermistor reports the measured temperature of the heatsink. This value is used for over temperature protections.

**T\_batt**

[16][0x00F] (C). *battery temperature*.

If the optional battery temperature sensor is attached, this variable reports measured battery temperature.

**V\_ref**

[17][0x010] (V). Regulation Voltage. Target voltage to which the battery will be charged. This value is temperature compensated.

**Ah\_r\_HI / Ah\_r\_LO**

[18,19][0x011,0x012] (Ah). *Resetable amp-hours*.

High and low bytes that record accumulated amp-hours. This amp-hour counter can be reset often to track short term Ah accumulations.

**Ah\_t\_HI / Ah\_t\_LO**

[20,21][0x013, 0x014] (Ah). *total amp-hours*. .

High and low bytes that record accumulated amp-hours. This amp-hour counter tracks accrued Ah for extensive periods of time.

**hourmeter\_HI / hourmeter\_LO**

[22,23][0x015, 0x016] (). *hour meter counter*.

Reports total hours of operation since installed.

**alarm\_HI / alarm\_LO**

[30,24][0x01D,0x017] (bit-field). *self diagnostic alarms*.

Reports alarms identified by self diagnostics. Each bit corresponds to a specific alarm. See appendix for alarm bits definitions.

**Note:** Alarm\_HI(0x001D) not addressable for software version 1.04.02 or older.

**fault**

[25][0x018] (bit-field). *self diagnostic faults*.

Reports faults identified by self diagnostics. Each bit corresponds to a specific fault. See appendix for fault bits definitions.

**dip\_switch**

[26][0x019] (bit-field). *dip switch positions*.

Each bit in the bit-field corresponds to an individual DIP switch setting. Useful for remote applications where access to TriStar to verify DIP positions is not feasible.

**control\_mode**

[27][0x01A] (V).

Reports the mode in which the controller is running.

0x00=charge

0x01=load

0x02=diversion

0x03=lighting

**control\_state**

[28][0x01B] (V).

Reports the current software state.

Value	Control State
Charge and Diversion Modes	
0	START
1	NIGHT CHECK
2	DISCONNECT
3	NIGHT
4	FAULT
5	BULK
6	PWM
7	FLOAT
8	EQUALIZE
Load and Lighting Modes	
0	START
1	NORMAL
2	LVD WARN
3	LVD
4	FAULT
5	DISCONNECT
6*	NORMAL OFF
7*	OVERRIDE LVD

\* these states apply only to Lighting Mode

**d\_filt**

[29][0x01C] (%) *duty cycle*. Reports the PWM regulation duty cycle, 0 to 100%.

The value ranges from 0 to 255, with 0 for 0% and 230 for 100% (values above 230 are also 100%).

**EEPROM Values**

EEPROM values that require updating are done so once every 24 hours.

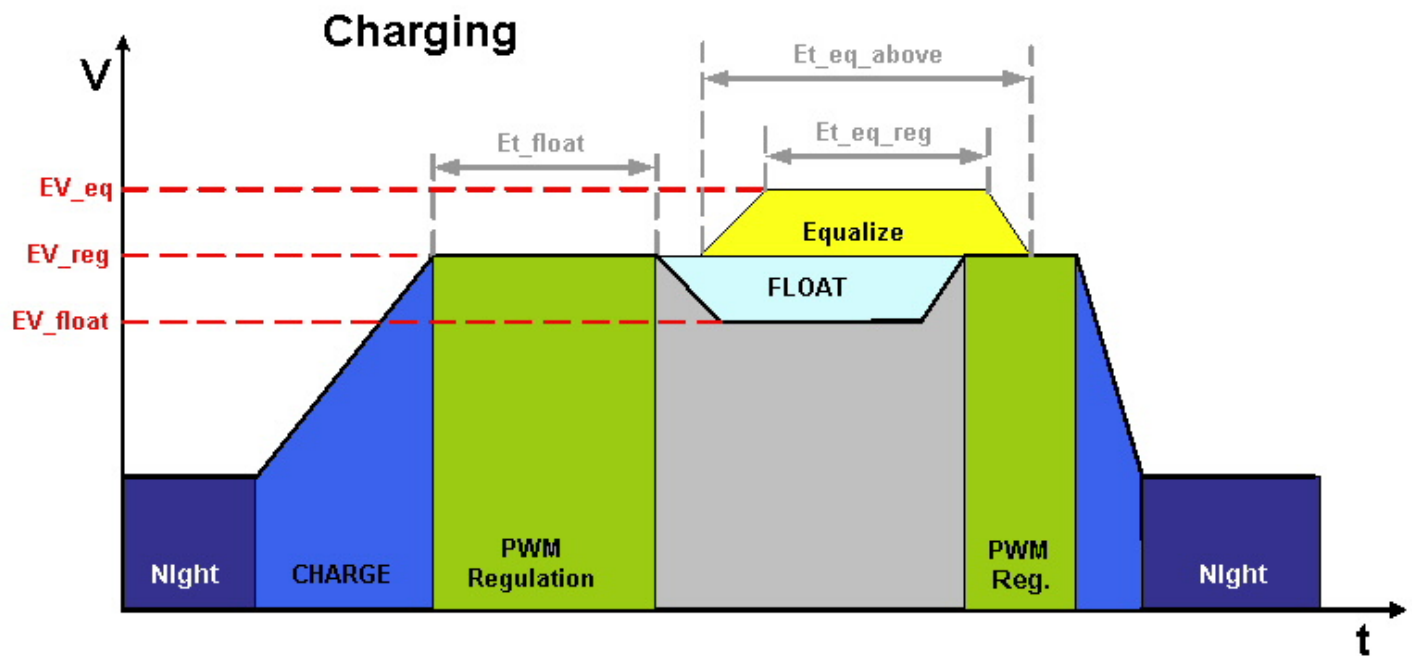
**Charging and Diversion Mode**

Diagram A Charging stages and defining variables.

**EV\_reg**

[57345][0xE000](V). *Regulation voltage @ 25°C.*

The battery will charge at 100% charge current until battery voltage reaches this setpoint. The controller will begin to taper input current so that this setpoint is maintained, but not exceeded. See diagram A.

## EV\_float

[57346][0xE001](V). *Float voltage @ 25°C*

After some period of time in regulation when the battery is fully charged, the battery will drop down to this lower setpoint to reduce gassing. See diagram A.

Set to zero to disable float stage

## Et\_float

[57347][0xE002] *time before entering float*

Defines the length of time in regulation before dropping down to the float stage. See diagram A.

## Et\_floatlb

[57348][0xE003] *time before entering float due to low battery*

If the battery voltage dropped too low during the previous night, this value allows the user to specify a longer period of time before entering float stage.

## EV\_floatlb\_trip

[57349][0xE004](V). *Voltage that triggers low battery float time*

Setpoint that will trigger a longer period of time before entering float. - See Et\_floatlb -

## EV\_float\_cancel

[57350][0xE005](V). *Voltage that cancels float*

Specify the battery voltage that will cancel float for the next charge cycle. If the battery discharged too low the previous night, the user may want to cancel float for the next day.

## EV\_eq

[57351][0xE006](V). *Equalize voltage @ 25°C*

The voltage setpoint to which the battery will be equalized. Periodic equalization equalizes cell voltages, bubbles the electrolyte, and helps prevent sulfation of the battery. See diagram A.

Set to zero to disable equalization

## Et\_eqcalendar

[57352][0xE007](days). *days between eq cycles*

Specify the number of days between equalizations. Equalizing on a calendar basis ensures proper maintenance of certain batteries.

## Et\_eq\_above

[57353][0xE008]() *equalize time limit above Vreg*

Equalization will timeout after the specified number of minutes above PWM regulation voltage. If the battery is charged above PWM regulation voltage but has not yet reached the equalization setpoint, this value serves as a safety timeout to prevent partial equalizations for extended periods of time. See diagram A.

**NOTE:** if the regulation method is set to ON-OFF, this variable alone will determine the equalization length.

## Et\_eq\_reg

[57354][0xE009] *equalize time limit at Veq*

Equalization will stop after the specified number of minutes at the equalization setpoint voltage. See diagram A.

## EV\_tempcomp

[57355][0xE00A](V/C). *temperature compensation.*

Battery chemistry changes with temperature. Determines the amount that regulation voltages will be shifted with temperature

## EV\_hvd

[57356][0xE00B] *High Voltage Disconnect @ 25°C*

Flag a fault/alarm if the battery voltage exceeds this setpoint. Also attempts to open the MOSFETs to stop charging/diversion.

Set to zero to disable HVD

## EV\_hvr

[57357][0xE00C] *High Voltage Reconnect*

The HVD fault/alarm will be cleared once the battery voltage drops below this setpoint.

## Etmr\_eqcalendar

[57358][0xE00D](days) *days since last equalize*

Counter that indicates the number of days since the last equalization was administered to the batteries.

## Et\_float\_exit\_cum

[57359][0xE00E](sec) *Cum. time at 100% duty cycle, exit float.* Specifies the cumulative amount of time at 100% duty cycle(i.e. not regulating input current), before the controller leaves the float stage. Reasons why the controller may reach 100% duty cycle include: a load on the battery or decrease in input current.

### Ed\_float\_enter

[57410][0xE041](%) *PWM duty cycle threshold that begins the Absorption to Float transition timer (Et\_float, Et\_floatlb).* Specify a duty cycle value between 0 and 100%. Default is 15%. Battery is more charged at lower duty cycles. High duty cycle values (~90%) will begin float timer almost as soon as battery reaches regulation. **Addressable in firmware v1.04.08 or higher.**

### Eb\_diversion\_pwm

[57411][0xE042](flag) *Specify PWM or On/Off method of regulation in Diversion Control mode.* A value of “1” written to this register will force the TriStar to regulate in On/Off regulation mode with a switching frequency of ~1Hz. For systems that experience PWM noise issues that cannot be resolved through other means, On/Off regulation forces the TriStar to switch very slowly, eliminating noise. Any other value written to the register specifies the default PWM regulation method (recommended). **Addressable in firmware v1.04.09 or higher.**



## Load Mode

### EV\_lvd

[57360][0xE00F](V). *Low Voltage Disconnect*

Setpoint to determine the load turn off voltage. When the battery has discharged too far, the load should be turned off to prevent over-discharge of the battery.

### EV\_lvr

[57361][0xE010](V). *Low Voltage Reconnect*

Battery setpoint that determines when the load will be reconnected. After the battery recharges to this setpoint, the load will be reconnected.

### EV\_lhvd

[57362][0xE011](V). *Load High Voltage Disconnect*

Disconnect the loads if the battery voltage rises too high. This function can protect DC loads that are sensitive to high input voltage.

Set to zero to disable HVD

### EV\_lhvr

[57363][0xE012](V). *Load High Voltage Reconnect*

Setpoint at which the loads will reconnect after a high voltage condition.

### ER\_icomp

[57364][0xE013](V/A). *LVD Load current compensation*

The LVD setpoint can be compensated in proportion to load current, lowering the disconnect value when the battery is under load. Note that the LED setpoints are also compensated accordingly.

### Et\_lvd\_warn

[57365][0xE014](sec). *LVD warning timeout*

Defines the period of time to wait before disconnecting the loads, once battery voltage has dropped to the Low Voltage Disconnect setpoint.

## Lighting Mode

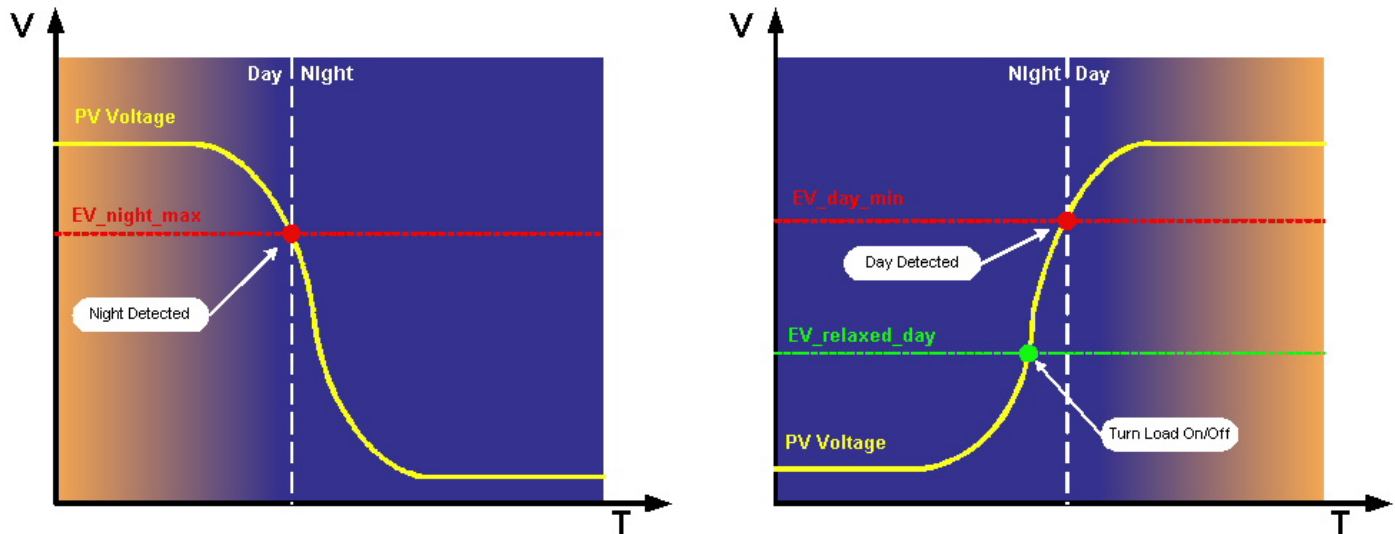


Diagram B Day/Night detection for lighting mode

### Et\_sun1

[57366][0xE015](min). *Lighting Timer for sunset*. Normally operates relative to sunset. For a negative value, it toggles the load BEFORE the predicted sunset time. For a positive value, it toggles the load AFTER sunset.

### Et\_sun2

[57367][0xE016](min). *Lighting Timer for sunrise*. Normally operates relative to sunrise. For a negative value, it toggles the load BEFORE the predicted sunrise time. For a positive value, it toggles the load AFTER sunrise.

### Eb\_light\_config

[57368][0xE017](bit-field). *Lighting Configuration Bits*. Four bits that determine if the load will toggle on or off when sunrise or sunset occurs. Also determines at which event (sunrise or sunset), each timer will start. See Appendix [Lighting Bits Configuration](#) for examples and description.

### EV\_night\_max

[57369][0xE018](V). *Night time threshold*

Array voltage setpoint at which night is determined.

See Diagram B.

**Note:** solar sense input on the sense terminals must be divided in half with an external resistor divider for 48V applications. Choose setpoints accordingly. Refer to lighting documentation for more info.

### EV\_day\_min

[57370][0xE019](V). *Morning threshold for timing*

Array voltage setpoint at which dawn is determined.

See Diagram B.

**Note:** solar sense input on the sense terminals must be divided in half for 48V applications. Choose setpoints accordingly. Refer to lighting documentation for more info.

### EV\_relaxed\_day

[57371][0xE01A](V). *Morning threshold for lighting*

Array voltage setpoint at which the load will be toggled ON/OFF. This setpoint is typically lower than the dawn voltage setpoint(EV\_day\_min), which is used for night length computation. This variable allows the user to increase the dawn detect sensitivity 10minutes before expected dawn.

See Diagram B.

**Note:** solar sense input on the sense terminals must be divided in half for 48V applications. Choose setpoints accordingly. Refer to lighting documentation for more info.

## Common

### EV\_soc\_g\_gy

[57372][0xE01B](V). *green to green/yellow limit*

LED transition setpoint. Specifies the battery voltage at which the LED state will change from Green to Green/Yellow.

### EV\_soc\_gy\_y

[57373][0xE01C](V). *green/yellow to yellow limit*

LED transition setpoint. Specifies the battery voltage at which the LED state will change from Green/Yellow to Yellow.

**EV\_soc\_y\_yr**

[57374][0xE01D](V). *yellow to yellow/red limit*

LED transition setpoint. Specifies the battery voltage at which the LED state will change from Yellow to Yellow/Red.

**EV\_soc\_yr\_r**

[57375][0xE01E](V). *yellow/red to red limit*

LED transition setpoint. Specifies the battery voltage at which the LED state will change from Yellow/Red to Red.

**ETb\_max**

[57376][0xE01F](C). *Max battery temp compensation limit*

Upper temperature setpoint at which the controller will no longer temperature compensate. Refer to graph .

**ETb\_min**

[57377][0xE020](C). *Min battery temp compensation limit*

Lower temperature setpoint at which the controller will no longer temperature compensate. Refer to graph .

**Emb\_tristar\_id**

[57378][0xE021](i). *Modbus TriStar server ID*

Modbus address which uniquely identifies the controller on the MODBUS network.

**Et\_batt\_service**

[57379][0xE022](days). *days between battery service intervals*

Specifies the number of days between battery service reminders. Sets an alarm, prompting the user to check his batteries for water, health, etc. Clear the alarm with the pushbutton, meter, or MODBUS alarm reset command.

**Etmr\_batt\_service**

[57380][0xE023](days). *days since last battery service*

Reports the number of days since the last battery service reminder.

**Ehourmeter\_LO / Ehourmeter\_HI**

[57381,57382][0xE024,0xE025](). *Hourmeter*

Cumulative hours the controller has been running. Non-volatile, written every 24hrs.

**EAh\_r\_LO / EAh\_r\_HI**

[57383,57384][0xE026,0xE027](). *Resettable Ah*

Cumulative amp-hours typically used for short-term logging. Resettable.

**EAh\_t\_LO / EAh\_t\_HI**

[57385,57386][0xE028,0xE029](). *Total Ah*

Cumulative amp-hours for long term logging. Can be reset if needed.

**EkWh**

[57387][0xE02A](kWh). *Kilowatt hours*

Cumulative kilowatt hours.

**EVb\_min**

[57388][0xE02B](V). *Minimum battery voltage*

Minimum battery voltage over last 24 hours. Written once every 24hrs.

**EVb\_max**

[57389][0xE02C](V). *Maximum battery voltage*

Maximum battery voltage over last 24 hours. Written once every 24hrs.

**Emb\_meterbus\_id**

[57409][0xE040](). *TriStar Meter Bus ID*

Address which uniquely identifies the controller on the Morningstar proprietary Meter Bus network.

Devices are daisy-chained on the Meter Bus network via the RJ-11 connections. Addresses are limited to the range of 1-15

## ***Calibration Values***

serial[1],[0] / serial[3],[2] / serial[5],[4] / serial[7],[6]  
[61441, 61442, 61443, 61444] [0xF000, 0xF001, 0xF002, 0xF003]  
serial number (8 byte ASCII string)

**K\_gain\_adc\_vb48**  
[61445] [0xF004] Battery voltage divider calibration, 48V mode

**K\_gain\_adc\_vb1224**  
[61446] [0xF005] Battery voltage divider calibration, 12/24V mode

**K\_gain\_adc\_ic**  
[61447] [0xF006] Charge current calibration

**K\_gain\_adc\_il**  
[61448] [0xF007] Load current calibration

**K\_gain\_adc\_vs**  
[61449] [0xF008] Sense voltage calibration

**K\_gain\_adc\_vx**  
[61450] [0xF009] Array/Load voltage divider calibration

**K\_hw ver (major, minor)**  
[61451] [0xF00A]  
MSB: hardware version major  
LSB: hardware version minor

**calib\_state, K\_amp60**  
[61452] [0xF00B]  
MSB: calib\_state = 0x5A if calibrated  
LSB: K\_amp60 = 0x01 if TS60, 0x00 if TS45

## ***Coils***

### **Equalize triggered**

[1] [0x0000] Trigger a manual equalize.

Will equalize while value =1. Reset value to 0 to stop equalize. Equalize will still timeout if not reset to 0.

### **Disconnect**

[2] [0x0001]

Force software into DISCONNECT state. Turns off MOSFETs and waits. To resume normal operation, set to 0.

(1 will force control into a disconnect state)

### **Clear Ah resetable**

[17] [0x0010]

Reset the resetable amp-hour counter back to 0.

(set only, will always read 0)

### **Clear Ah total**

[18] [0x0011]

Reset the total amp-hour counter back to 0.

(set only, will always read 0)

### **Clear kWh**

[19] [0x0012]

Reset the total kilowatt-hour counter back to 0.

(set only, will always read 0)

### **Reset batt service reminder**

[20] [0x0013]

Reset the days since last battery service counter to 0.

(set only, will always read 0)

### Clear faults

[21] [0x0014]

Clears the faults bit field. Certain faults require 10sec before retry(short circuit, over-current, etc). Control will not allow reset of these faults until 10sec counter has expired. Faults that require a power cycle or controller reset cannot be cleared by this coil (e.g. DIP SW change)  
(set only, will always read 0)

### Clear alarms

[22] [0x0015]

Clears the alarms bit field.  
(set only, will always read 0)

### Force EEPROM update

[23] [0x0016]

Force the controller to update EEPROM with RAM values.  
(set only, will always read 0)

### LVD override

[24] [0x0017]

Force the controller out of LVD in Load and Lighting mode. If Vbatt is still below LVD the load will run for a length of time specified by Et\_lvd\_warn, then return to the LVD state. If Vbatt is above LVD, the load will remain connected.  
(set only, will always read 0)

### Reset control

[256] [0x00FF]

Reset control will force a reboot of the processor software. Useful for clearing faults/alarms after settings changes, or firmware updates.



## Examples

### *Scaling*

Scaling Battery voltage, filtered ( $\tau \approx 2.5\text{s}$ )

Read Holding Register Value: 0x1007

Scaling for this variable:  $n \cdot 96.667 \cdot 2^{-15}$

1007 hex  $\rightarrow$  4103 dec

$(4103 \times 96.667) / 32768 = 12.1\text{V}$

## Appendix

### *Alarm Bits Table*

Alarm Bit field PDU addresses 0x0017 (LO) and 0x001D (HI)

<b>BIT</b>	<b>ALARM</b>
0	RTS open
1	RTS shorted
2	RTS disconnected
3	Ths disconnected
4	Ths shorted
5	TriStar hot
6	Current limit
7	Current offset
8	Battery Sense
9	Batt Sense disc
10	Uncalibrated
11	RTS miswire
12	HVD
13	high d
14	miswire
15	FET open
16	P12*
17	Load Disc.*
18	Alarm 19*
19	Alarm 20*
20	Alarm 21*
21	Alarm 22*
22	Alarm 23*
23	Alarm 24*

**\*Note:** Alarm\_HI(0x001D) not addressable for software version 1.04.02 or older.

### *Fault Bits Table*

Fault Bit field PDU address 0x0018

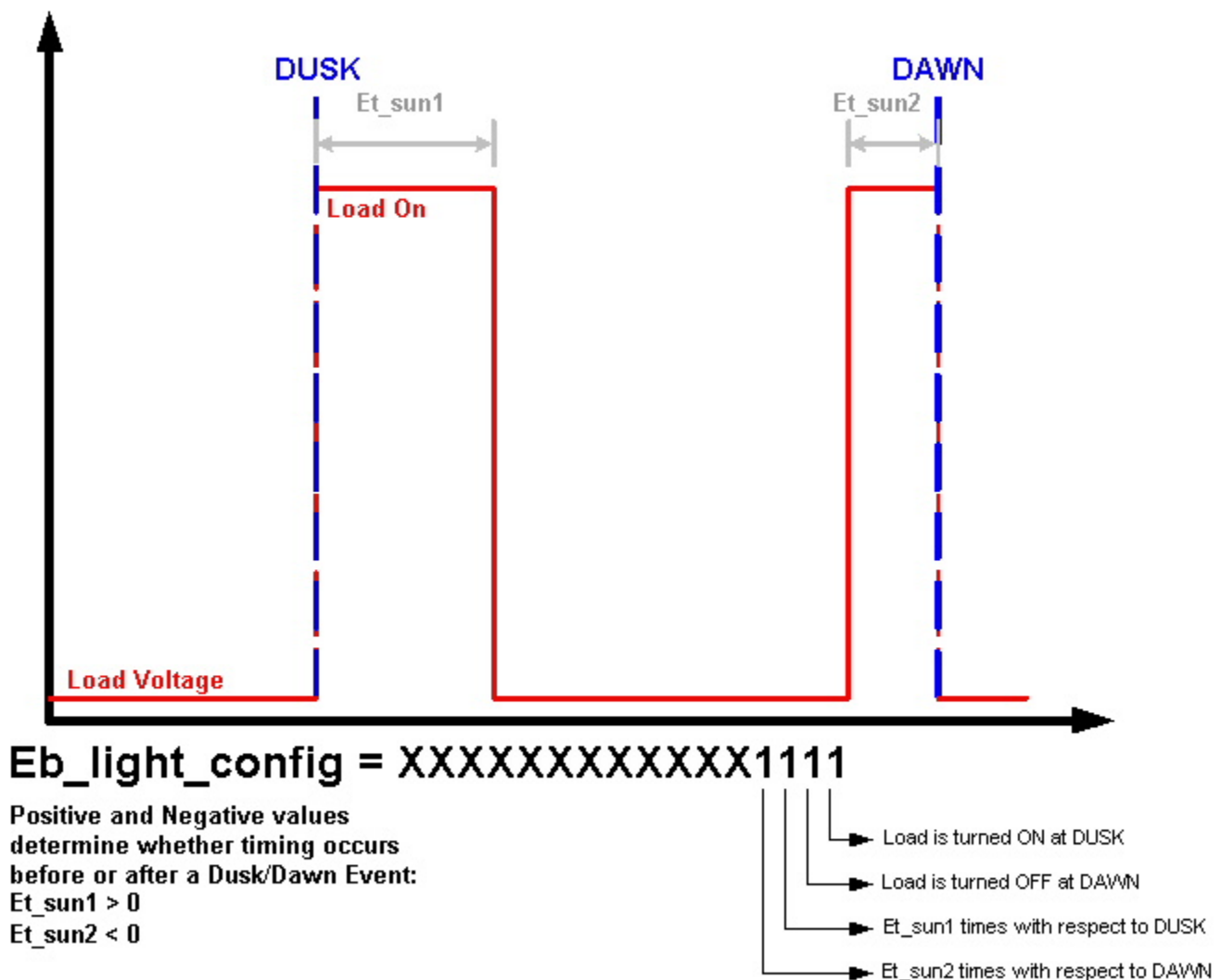
<b>BIT</b>	<b>FAULT</b>
0	External Short
1	Overcurrent
2	FET short
3	Software
4	HVD
5	TriStar hot
6	DIP sw changed
7	Setting edit
8	reset?
9	Miswire
10	RTS shorted
11	RTS disconnected
12	Fault 12
13	Fault 13
14	Fault 14
15	Fault 15

## Lighting Bits Configuration

Following are a few examples to illustrate the function of the lighting configuration bits, which are the 4 LSBs of Eb\_light\_config. All other bits in the field are ignored.

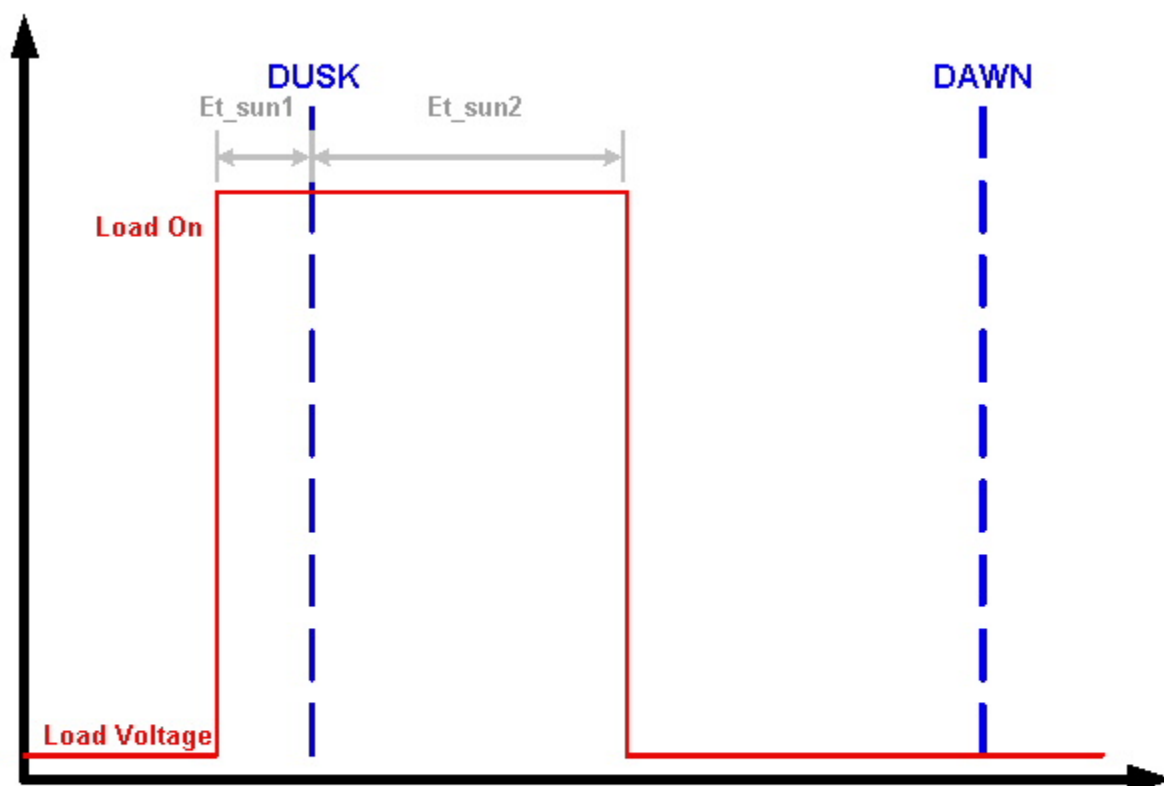
### Example 1

**On After Dusk for X hours. On Before Dawn for Y hours.**



## Example 2

On Before Dusk for X hours. On After Dusk for Y hours.



**Eb\_light\_config = XXXXXXXXXXXXX0111**

Positive and Negative values  
determine whether timing occurs  
before or after a Dusk/Dawn Event:

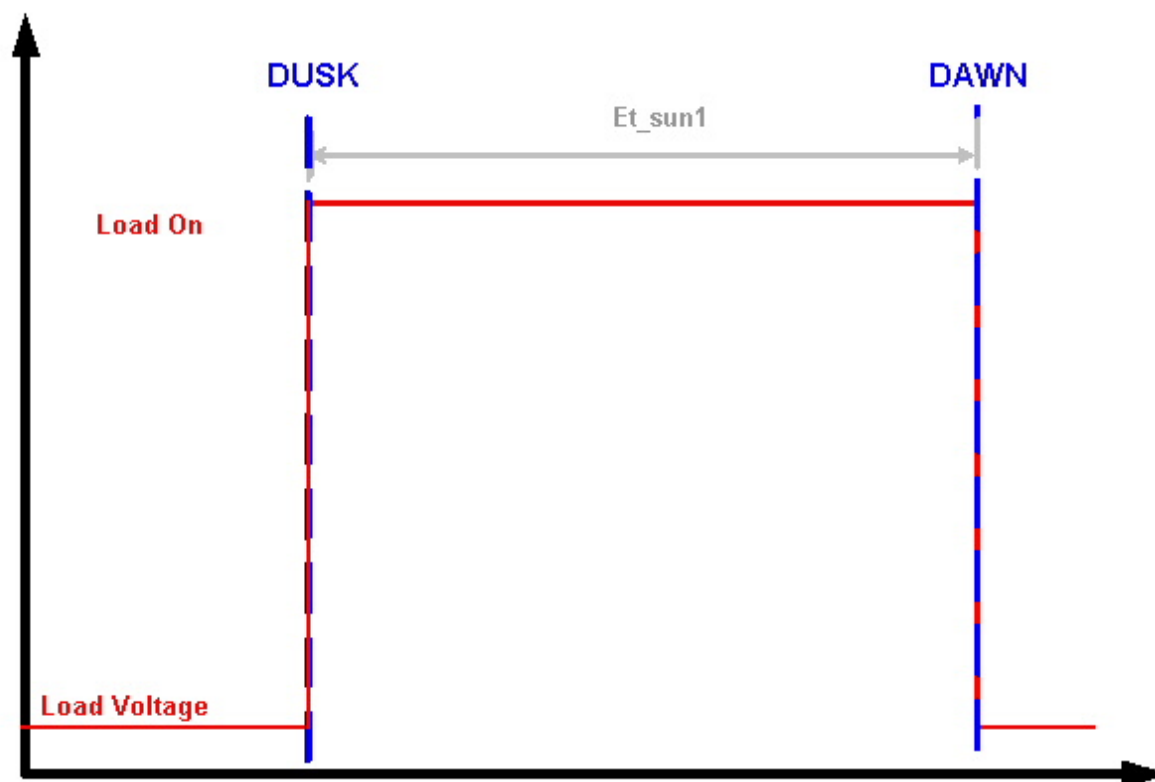
Et\_sun1 < 0

Et\_sun2 > 0

- Load is turned ON at DUSK
- Load is turned OFF at DAWN
- Et\_sun1 times with respect to DUSK
- Et\_sun2 times with respect to DUSK

### Example 3

#### On Dusk to Dawn



**Eb\_light\_config = XXXXXXXXXXXXXXX111**

Positive and Negative values  
determine whether timing occurs  
before or after a Dusk/Dawn Event:  
Et\_sun1 > Night Length  
Et\_sun2 = 0

- Load is turned ON at DUSK
- Load is turned OFF at DAWN
- Et\_sun1 times with respect to DUSK
- Since Et\_sun2 is set to zero, this bit no longer matters.

## References

- Modbus Protocol Reference Guide, Modicon, June 1996, PI-MODBUS-300 Rev.J
- Modbus Application Protocol Specification, modbus.org, 8May02,
- Modbus\_application\_protocol\_v1

## Document Revision History

### 1.0.0 (up to firmware version 1.04.06)

- First release

### 1.0.1 (firmware version 1.04.08 and later)

- Added EEPROM value *Ed\_float\_enter*. Allows modification of PWM% threshold to begin float stage transition timer.

### 1.0.2 (firmware version 1.04.09 and later)

- Added EEPROM value *Emb\_meterbus\_id*. Allows modification of TriStar id on the Meter Bus network.
- Added EEPROM value *Eb\_diversion\_pwm*. Allows adjustment of regulation type in Diversion mode. PWM or On-Off charging. Charging Mode uses DIP switches for this setting, diversion mode does not have a DIP switch for this setting. 0 = PWM, 1 = On/Off.
- Correction of scaling for Ah HI and LO in EEPROM

### 1.0.3 (firmware version 1.04.13 and later)

- Added Logged Data records/register information.

### 1.0.4 (firmware version 1.04.13 and later)

- Changed nine (9) pairs of hexadecimal and logical EEPROM addresses consecutively from 1.0.3 values 0xE024/57381 through 0xE02C/57389